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AN ESTIMATE OF NASA/ESE/POWER PROGRAM BENEFITS TO THE U.S. FROM 2002 THROUGH 2017

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EXECUTIVE SUMMARY

This document provides a first analysis of benefits to the United States energy industry if the proposed NASA Earth Science Enterprise (ESE) Prediction Of World Energy Resources (POWER) project is approved. The POWER project proposes to coordinate with various agencies, industry associations, and companies to convert appropriate ESE radiation and meteorology science data over the globe into industry-specific parameters and formats for incorporation into industry and other-agency government Decision Support Systems (DSS). Results suggest that the ratio of U.S. energy-industry benefits to assumed NASA costs is approximately 12,400:1 for the 2002 through 2017 time period. Uncertainty is ± 50% because benefits to other industries were not included and some needed data are either uncertain or unavailable at this time.

LIMITATIONS

Some industry and government segments could not be considered in this first analysis because of both time and resource limitations. These omitted segments combined may ultimately have benefits as large as those of the energy industry that was considered.

This analysis does not include dollar benefits for the large number of new jobs (870,000, Renewable ENERGY World, November-December, 2000) to be created in the renewable energy industry as it matures and becomes larger. Use of POWER data in remote regions where data are not available will enhance industry expansion and help create maybe 10% of the new jobs. The industry both manufactures and installs equipment in the U.S. and foreign countries.

The analysis also ignores the residential portion of the building industry. That segment of the industry is large, however, individual projects are small-scale with short-term incentives at the present time. In the longer term, renewable energy technologies and commercial construction techniques will filter down to the residential market and benefits will become large.

The analysis also does not include U.S. company building design and construction participation in foreign projects. That market is significant, particularly for that segment of the industry that supports Department of Defense and other U.S. government agency installations in foreign countries.

It is difficult to quantify benefits to operation of the federal government outside the energy industry. We know that existing POWER/Surface meteorology and Solar Energy (SSE) historical data are being used by the Department of Defense (DOD), the Department of Energy (DOE), Centers for Disease Control, etc. The data are used to more completely define the meteorological environment in remote regions of the globe for the design/development of future hardware systems and operational planning. Benefits to the public of these types of activities are unpredictable.

Finally, we do not estimate benefits to the U.S. food industry from POWER techniques created for the biomass energy industry as part of this study.

SOLAR AND WIND PORTIONS OF THE RENEWABLE ENERGY INDUSTRY
(Includes Photovoltaic, Solar Thermal, and Wind Systems)

The cost of 10^6 BTU of typical mixed energy types is ~$13.50 in Y2K nominal, non-inflation adjusted dollars (DOE Annual Energy Review 2000, http://www.eia.doe.gov/emeu/aer/aerpdf.html), hereafter referred to as DOE Y2K Annual Review. The basic unit of energy is 10^{15} BTU = 1 quad. Therefore, 1 quad of energy cost ~$13.50 x 10^9. The DOE Y2K Annual Review suggests that Y2K solar/wind portion of the renewable industry size = 0.12 quad BTU = $1.62 x 10^9 for all types of U.S. consumption.

Natural Resources Canada (NRCan) has unofficially suggested that POWER/SSE data benefits industry expansion and the resulting displacement of petroleum-based energy. NASA data allows system design in regions where environmental information is incomplete or does not exist. Benefits are probably between 10% and 20% of renewable energy values. We assume that SSE Release 3 benefits 10% of this U.S. industry ($.16 x 10^9 in Y2K dollars). It is reasonable to assume that Release 4 with winds, direct normal radiation, and tilt-surface information in combination with future ESE science updates will help maintain a benefit of 10% of industry value well beyond 2003.

Various sectors of the renewable energy industry are expected to grow at different rates ranging from 2.4% (solar thermal) to 3.7% (wind) to 19% (photovoltaics) per year according to DOE's National Energy Modeling System (NEMS) (from Macauley et al. Resources for the Future Discussion Paper 02-05, February 2002, http://www.rff.org). If the above growth rates are weighted in accordance with their respective production magnitudes, an average growth rate of 4% is obtained for the combined three systems over the period 2001 through 2020 because wind is the largest producer of energy.

Macauley et al. note that NEMS has been criticized for its assumptions concerning market penetration and other characteristics of its modeling and forecasting approach. In particular, another DOE study (Osborn et al., http://enduse.lbl.gov/Projects/NEMSwind.html) indicates that NEMS wind industry growth may be as much as 53%/yr instead of 3.7%. NEMS is clearly different than recent wind energy growth rates (~40%/yr). If wind were to grow at a 40% rate instead of 3.7%, the weighted-average yearly growth rate for the combined solar thermal, photovoltaic, and wind sectors would be slightly less than 40%.

Picking a middle range, growth of the combined solar and wind U.S. renewable energy industry is assumed to be 25% in this analysis. POWER/SSE benefits in constant Y2K dollars are estimated to be:

YEARLY BENEFITS FOR SOLAR AND WIND PART OF THE RENEWABLE ENERGY INDUSTRY
(10^9 Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.25	0.31	0.39	0.49	0.61	0.76	0.96	1.20	1.50	1.87	2.34	2.92	3.65	4.56	5.70	7.13

The values essentially amount to industry expansion resulting in savings of petroleum-based energy costs.

ARCHITECTURE/BUILDING INDUSTRY

The DOE March 2001 Monthly Energy Review gives Y2K primary energy consumption as 98.8 quads, an all time record. Residential and commercial building energy consumption is 36.4% of primary consumption or $486 x 10^9 in constant Y2K dollars. Commercial buildings are 45% ($219 x 10^9) of that total (Environmental Building News, May 2001, from 1995 Commercial Buildings Energy Consumption Survey, DOE). Accounting for the number of buildings, average energy expenditures per building were:

4.6 x 10^6 commercial buildings average = $48,000/yr

101.5×10^6 residential buildings average = $2,600/yr

(We ignore the residential segment of the building industry for the remainder of this analysis because both industry and customers have mixed small-scale time/cost/reliability incentives at this point in time.)

New commercial buildings (170,000/yr) can have 50% reduced energy requirements at no increase in construction costs (various DOE reports and Environmental Building News, May 2001, from A Characterization of Building-Related Construction and Demolition Debris in the United States, EPA, 1998). Atmospheric data MUST be available for design of daylighting, auxiliary renewable energy power on roofs, accounting for winds, solar geometry, etc. Over 200 building-design software programs are now available from various sources. Unfortunately, these design programs often are not used to maximum advantage because neither the building nor the architectural industries can easily obtain the atmospheric data except at 239 major cities of the U.S. It is a major problem when companies wish to bid on construction projects in foreign countries, a significant segment of both the civilian and government/military segments the industry.

It is reasonable to expect that a web-based buildings/architectural data source would experience the same type of success as the renewable energy NASA/ESE/SSE web site enjoyed. There are 10 to 20 times more potential users for buildings/architectural data than there are renewable energy industry users (2000 U.S, 7200 global, at the present time). For many users and potential construction sites, this would be the only near-complete data available. A 20% impact on the new construction industry may be reasonable.

It is expected that a prototype NASA/ESE/POWER buildings/architectural web site would be available for industry testing by mid-FY 2003 with a final version in mid-FY 2005. By that time, industry usage should be such that benefits should be around 10% of new commercial building construction.

New commercial construction is (170,000/4,600,000) = ~3.7%/yr of the existing number of commercial buildings. Using conventional technology, energy consumption would increase by $\$8.1 \times 10^9$ per year from new building construction. We assume no expansion in the new buildings industry within the U.S. relative to constant Y2K dollars. (That is not the situation over the globe where U.S. companies are participating.) Assuming a 20% impact on U.S. new building construction energy growth, benefits are as follows:

YEARLY BENEFITS TO THE NEW-CONSTRUCTION ARCHITECTURE/BUILDING INDUSTRY
(10^9 Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0	0.81	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62

The above benefits do not include benefits to be obtained from renovated-building construction. Assuming major renovation every 25 years, the average number of renovation buildings per year is (4,600,000/25) = 184,000. The amount of energy used in these renovated buildings is (184,000/4,600,000) x ($219 x 10^9) = $\$8.76 \times 10^9$. Existing construction will severely restrict the application of new technologies in many cases. We assume 5% impact on renovation construction energy growth in the commercial buildings/architectural industry.

YEARLY BENEFITS TO THE RENOVATION-CONSTRUCTION ARCHITECTURE/BUILDING INDUSTRY
(10^9 Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0	0.22	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44

These values also essentially amount to savings in petroleum-based energy costs.

BIOMASS ENERGY

The DOE Y2K Annual Review indicates that the U.S. biomass energy industry in Y2K was about 3.3 quad or $\$44.6 \times 10^9$ in size. DOE projections published in SOLAR TODAY (June/July, 1997) indicate that the industry growth rate is expected to average about 50%/yr through 2020. New crop species and processing technologies are expected lower the price of ethanol to 30% of present values, greatly increasing market penetration (Renewable ENERGY World, May-June, 2000). In the very long term, global bioethanol energy is expected to equal 37% of the world's 1998 petroleum consumption. It should be noted that the Resources for the Future Discussion Paper 02-05 (Macauley et al.) indicates that the DOE NEMS model shows only 2.9%/yr market growth for electrical energy generation. Major biomass energy consumption includes several industries, (transportation, chemical manufacturing, electrical energy and heating), however. It should be noted that DOE has recently created a new center for biomass energy research.

Much of the U.S. biomass industry is regional at this time to reduce transportation costs of the fuel from the farm to the processing plant. As the industry becomes larger, fuel supply will probably be international in nature because of growing season limitations in most regions. It will probably take on the nature of the food/commodities markets of today. The U.S. will probably be a major supplier to some other regions of the globe.

The NASA role in biomass energy probably will concern agricultural aspects of crops used for fuel. Historical global data sets of agricultural crop growth parameters based on temperature, rainfall, radiation, and wind data would follow procedures similar to those developed during the NASA/ESE/SSE project. These historical weekly data would provide both normal and abnormal conditions that would aid crop selection and provide pest/disease potential.

Near-real-time hindcasts and forecasts on a weekly basis would give individual growers information on crop progress and alert to the possibility of pest/disease outbreak. Most important, it would allow estimates of the time of harvest or be one DECISION TOOL for abandoning the crop to make the land available for other alternatives. Such capabilities would allow energy producers and trading markets information for assessment of fuel supply from another global region during the non-growth season at a particular processing plant. These same capabilities would aid the U.S. food industry.

If longer-term forecasts are proven accurate, biomass energy fuel supply variations could be predicted and accounted for by adjusting other fuel sources.

The agricultural community has many predictive services available to it now. Our information is that none of the present services are as easy to obtain or of the same type (global multi-parameter) as proposed by the POWER project. In the long term, the NASA site would be turned over to NOAA, USDA, DOE, or an industry association or company for operation.

We are not able to estimate market penetration at the present time. For purposes of this preliminary analysis, we make a baseline assumption that energy resource planning activities will have 1% impact on the biomass market under usual operating conditions. Benefits of energy prediction will not begin until 2008. We assume that biomass energy consumption will expand at a 25%/yr rate, between the two DOE estimates. Benefits under these assumptions are:

YEARLY BENEFITS TO BIOMASS ENERGY INDUSTRY
(10^9 Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0	0	0	0	0	2.12	2.66	3.32	4.15	5.19	6.49	8.11	10.1	12.7	15.8

As noted above, there is wide uncertainty in biomass benefits as a result of uncertainties in market growth, market penetration, and spin-off to the agricultural industry.

ENERGY RESOURCE PLANNING

In Y2K, the total U.S. energy supply was 102.6 quads worth ~$1385 x 10^9. The breakdown was:

Crude Oil	36.0%		
Natural Gas	27.2%		
Coal	22.4%		
Nuclear	7.8%		
Renewables	6.6%	includes:	
		biomass	3.3%
		hydro	2.84%
		geothermal	0.34%
		solar thermal	0.066%
		wind	0.050%
		solar PV	0.004%

(Total U.S. energy consumption was only 98.5 quads due to a small amount of exports to other countries and adjustments.)

Energy planning using weather and climate data influences selected segments of both the energy supply and energy consumption sides of the industry. On the supply side, only renewable sources (6.82 quad) are influenced. Weather and climate influences use of fossil fuels, nuclear electric power, and renewable energy (98.7 quad total) on the consumption side. POWER weather and climate will influence 105.52 quads of energy flow that amounts to about $1424.5 x 10^9 in constant Y2K currency.

Benefits of predictive information will differ in each of the energy sectors. Impacts will probably be as high as 20% in some renewables, but very low in some consumption areas such as manufacturing. Penetration will be strongly dependent on the reliability and accuracy of the predictive methods developed under the POWER project that are not yet known.

For purposes of this analysis, we make the conservative assumption that energy resource planning activities will have 1% impact on the combined energy market under usual operating conditions. Benefits of energy prediction will not begin until 2008. We assume that energy consumption will continue to expand at a 5%/yr rate similar to the 1990 to 2000 period. Benefits under these assumptions are:

YEARLY BENEFITS OF NASA/POWER ENERGY RESOURCE PLANNING
(10^9 Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0	0	0	0	0	1.56	1.64	1.72	1.80	1.89	1.99	2.09	2.19	2.30	2.42

The above values are very preliminary and should be updated when more complete information can be obtained.

If unexpected crisis situations develop in the energy market, the value of predictive capabilities will magnify significantly depending on the particular segment and size of the population involved. Such events are difficult to predict.

YEARLY SUMMARY OF BENEFITS FOR ALL PHASES OF THE POWER PROJECT
(10^9Y2K$)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.25	0.31	1.42	2.55	2.67	2.82	6.70	7.56	8.60	9.88	11.5	13.5	15.9	18.9	22.8	27.4

YEARLY RATIO OF BENEFITS TO NASA COST
(10^3)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.67	0.78	1.85	2.69	2.24	2.29	5.33	5.84	6.62	7.59	9.59	12.2	159K	189K	228K	274K

NOTE: Years 2014, 2015, 2016, and 2017 assume only $100K of NASA cost to maintain communications with organizations using the POWER data in their decision tools. Benefit to cost ratios are very high for those years.

16-YEAR SUMMARY OF BENEFITS AND COSTS

* Benefits for the period = $153 Billion $\pm$ 50%.

* NASA costs are assumed to be $12 Million for the period.

* Total benefits/NASA cost ratio for the POWER project ~ 12,400:1 $\pm$ 50%.